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Discussion

Dr Munir Boodhwani *(Brussels, Belgium).* Can you comment on your power and sample size calculations? It is a smallish study with negative results. What were your assumptions?

Dr Singh. In our original protocol and proposal for funding, we hypothesized and calculated that roughly 200 patients would be required per arm. This would achieve a power of 80%, given an assumed event rate in the control group of 9% of grafts occluded, with a relative risk reduction of 60%. Although we did not actually recruit our intended sample, the event rate, occlusions in the control group, was significantly higher at 30%. As well, the relative risk reduction confidence interval included that which we had hypothesized. On the basis of these parameters, it is reasonable to assume a reasonable power and to make a meaningful conclusion from this study.

Dr Boodhwani. Was the harvesting technique for the saphenous vein similar in both groups?

Dr Singh. The method was standardized in both groups; it was the conventional, open, nonminimally invasive harvesting technique.

Dr Jennifer Sue Lawton *(St. Louis, Mo).* You should be commended on your low rate of graft revision despite imaging. In St Louis, we do not have our hybrid operating room ready yet, so the only thing I can really use for off-pump CABG is the flow probe. It looked like part of your imaging was flow probe assessment. Do you have any data to correlate your imaging with flow probe information? In other words, would flow probe data alone have prompted you to revise your grafts without the angiography data?

Dr Singh. That is an excellent question. We used both techniques in collaboration, because the evidence from our institution has shown that the flow probe is more sensitive to complete occlusions and the ICG technique was more sensitive to nonocclusive disease.

When we looked at the grafts that were not revised, at 1-year follow-up angiography, we looked at the mean pulsatility indexes, the mean diastolic flow fractions, and the mean flows. Actually, there was no difference in those that ultimately were occluded and those that were not. However, most grafts that were revised had more findings on the TTF than on the ICG. Thus there was more of a predilection for revision with positive TTF findings.

Dr Beat H. Walpoth *(Geneva, Switzerland).* We pioneered the TTF measurements 15 years ago. I think it is a nice study, but I am not sure whether you can predict the flow at a 1-year follow-up based on the initial flow. It would be marvelous, but it is so complex; there are so many factors. However, on the other hand, you had several revisions during surgery owing to bad flow or bad visualization of the graft. Therefore, I think you cannot support your conclusion, because your conclusion says that you should measure flow only in high-risk patients and sporadically. The point is, actually, that you should measure all grafts. This takes 1 minute per graft, and if you measure all grafts you will not miss patients in whom you should do a revision on site. That is how you will improve your patency in the long run. Could you comment on these aspects?

Dr Singh. What we have gleaned from our study is that there is a need for improving quality assurance and that intraoperative tools can identify potential errors and poorly constructed grafts. However, we also identified that perhaps there is still a role for clinical judgment by surgeons as to what grafts are critical and at high risk for failure, requiring revision, or what grafts should not be revised if the outcome would be poorer patency owing to technical challenge, but may not dramatically influence outcomes. As such, the collaboration of clinical judgment with objective evidence from intraoperative tools probably is what best leads to improving patency

and avoiding inappropriate graft revisions. As we have seen, although it is hard to make a meaningful conclusion from a smaller number, some of the grafts that met revision criteria, but were not revised because of attending surgeon judgment, were still patent at 1-year follow-up angiography. I think we should not go full force to say we should use it routinely; however, targeted use of clinical judgment would probably be most ideal.

Dr Walpoth. One follow-up question: If you had only one technique, which one would you prefer?

Dr Singh. Evidence from our institution, comparing ICG to TTF to the gold standard, x-ray angiography, has shown that the sensitivity and specificity of ICG for 50% to 90% stenoses and 100% stenoses is superior to that of TTF. TTF has a sensitivity and specificity for nonocclusive disease much poorer than that of ICG. Thus ICG might provide more data. Besides that, it is much more user friendly and better provides an image that attending surgeons can easily interpret as opposed to just interpreting numbers that are provided by TTF.

Dr Keith Horvath *(Bethesda, Md).* This was an excellent presentation of a difficult study to conduct. Some might assume a conclusion from this trial is that hybrid operating rooms are not really needed, because you have done a nice job showing that imaging really did not have a significant impact at the time of surgery. I am wondering whether that is a fair conclusion. My second question is this: You have demonstrated that there are many factors responsible for graft failure and that the technical aspects at the time of the grafting, although they play a role, are probably not as high of a factor in causing graft failure as we think. From what you have been able to see in the grafts that failed, was there any either qualitative or semiquantitative assessment of the distal vessel that may have been the reason for those failures? Did you learn anything in that regard? The extent of target vessel disease is probably still a much more important factor in graft failure than the technical aspects of the operation.

Dr Singh. Thank you for those two questions. Your first question concerned the role of imaging and queried the involvement of evolution of hybrid operating rooms. I think there still is a role for imaging, especially in the evolution of hybrid operating suites, because in many situations what is being done is minimal access, lower exposure, beating heart procedures. As such, these are the patients that are probably at high risk for poorer construction of distal anastomoses and, as such, intraoperative angiography or imaging should have a role.

With respect to your second question, we did note that the graft revision rate was quite low and that the occlusions at 1 year obviously are multifactorial. Many things contribute to this, including distal target characteristics. We have not looked at it in the present study, but we will be looking at the data and comparing them. One would anticipate that the degree of distal disease and the native vessel characteristics, as has been shown in the literature, would play a role in 1-year patency; however, given the randomization of the study, we believe the impact should have been balanced.